Storypoint Problem Exploration - mesos

September 4, 2024

1 Storypoint Prediction: Problem Exploration

1.1 Problem Statement

In modern agile development settings, software is developed through repeated cycles (iterative) and in smaller parts at a time (incremental), allowing for adaptation to changing requirements at any point during a project's life. A project has a number of iterations (e.g. sprints in Scrum). Each iteration requires the completion of a number of user stories, which are a common way for agile teams to express user requirements.

There is thus a need to focus on estimating the effort of completing a single user story at a time rather than the entire project. In fact, it has now become a common practice for agile teams to go through each user story and estimate its "size". Story points are commonly used as a unit of measure for specifying the overall size of a user story.

1.2 Problem Formulation

Input: A string of length N that contains a story's name and description $C = \{c_1, c_2, c_3, ..., c_n\}$. For each story, a set of text embeddings that contains features $E = \{e_1, e_2, e_3, ..., e_m\}$ extracted from C has been provided.

Output: A natural number P associated with the story point of that user story

1.3 Dataset Information

Text Embeddings: Text embeddings are a way to convert words or phrases from text into a list of numbers, where each number captures a part of the text's meaning. The dataset has been preprocessed and converted into two kinds of text embeddings. You can choose to work with either of them or both: - Doc2Vec: Input strings are transformed into fixed-length vectors of size 128. These vectors capture the semantic meaning of words and their relationships within a document. - Look-upTable: Input strings are transformed into fixed-length vectors of size 2264. These vectors are obtained via transforming each word in the input strings into an identifier number, then padded to the length of the longest sample.

Dataset Structure & Format: Storypoint Estimation Dataset is stored in 3 folders labeled *raw data*, *look-up*, and *doc2vec*. Within each folder are 3 CSV files for training, testing, validation. Each csv file has the following columns: - `issuekey` : The unique identifier for a story. - `storypoint`: The correct number of storypoint. - An embedding column (`embedding` or `doc2vec`) contains text embedding vectors. The raw data csv will not have this and instead contain two columns with story `name` and `description`.

1.4 Exploration

1.4.1 Raw data exploration

[ ]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.feature_extraction.text import CountVectorizer
```

Output exploration

[ ]:
```python
# Import raw data from the CSV file

project_name = 'mesos'

all_data = pd.concat([pd.read_csv('data/' + project_name + '/' + project_name +␣
 ↪'_train.csv'),
                      pd.read_csv('data/' + project_name + '/' + project_name +␣
 ↪'_valid.csv'),
                      pd.read_csv('data/' + project_name + '/' + project_name +␣
 ↪'_test.csv')])

print('Check the shape of the dataset', all_data.shape)
```

```
Check the shape of the dataset (1562, 4)
```

[ ]:
```python
all_data.drop(['issuekey'], axis=1, inplace=True)
all_data.head()
```

[ ]:
```
                                             title  \
0  report executor terminations framework schedulers
1                             mesos slave cache executors
2                    expose taskfailed reason frameworks
3            balloon framework fails run due bad flags
4  also check git diff shortstat staged postrevie…

                                       description  storypoint
0  scheduler interface callback executorlost curr…           2
1  slave smarter handles pulling executors enviro…           5
2  message string inside taskstatus provides huma…           8
3  suspect latest flags refactor vinodsmfdbkqsr b…           1
4  current check changes run postreviewspy dont c…           1
```

First, let take a look at the distribution of the story point:

Interpretation of Skewness Values:

- **Skewness > 0**: Right-skewed distribution.
- **Skewness < 0**: Left-skewed distribution.

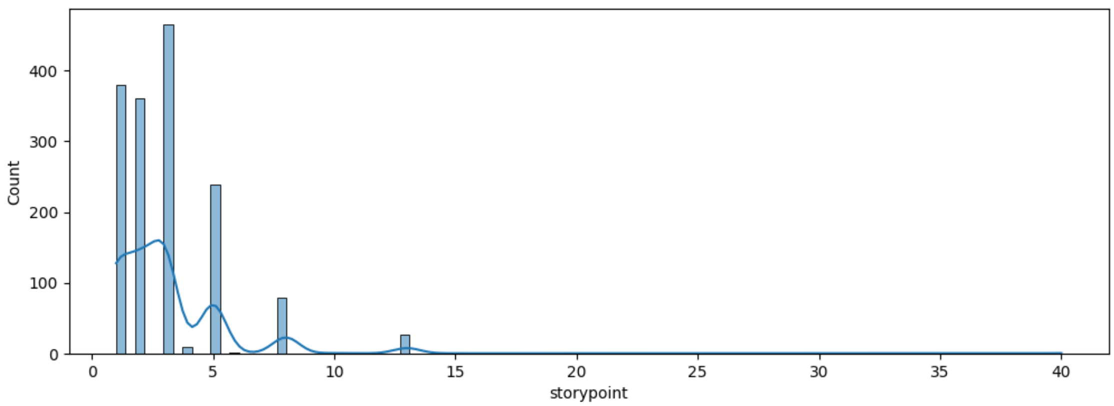
- **Skewness = 0**: Symmetrical distribution (like a normal distribution).

Interpretaion of kurtosis: - **Leptokurtic (Kurtosis > 3)**: The distribution has heavier tails and a sharper peak than the normal distribution. Data points are more likely to produce extreme values. The distribution has a higher peak and fatter tails. - **Platykurtic (Kurtosis < 3)**: The distribution has lighter tails and a flatter peak than the normal distribution. Data are fewer extreme values compared to a normal distribution. - **Mesokurtic (Kurtosis 3)**: The distribution has a similar kurtosis to the normal distribution, indicating a moderate level of outliers.

[ ]:
```python
# Draw a histogram of the story points
plt.figure(figsize=(12, 4))
plt.xticks(np.arange(0, max(all_data['storypoint']) + 1, 5))
sns.histplot(all_data['storypoint'], bins=100, kde=True)

print('Skewness:', all_data['storypoint'].skew())
print('Kurtosis:', all_data['storypoint'].kurt())
```

```
Skewness: 4.007223252844538
Kurtosis: 40.68919923889905
```



[ ]:
```python
tmp = pd.concat([all_data['storypoint'].value_counts(),
                 all_data['storypoint'].value_counts() / all_data.shape[0] *␣
 ↪100],
                axis=1, keys=['Counts', 'Percentage (%)'])
tmp.head(20)
```

[ ]:

storypoint	Counts	Percentage (%)
3	465	29.769526
1	380	24.327785
2	361	23.111396
5	239	15.300896
8	79	5.057618
13	26	1.664533

4	9	0.576184
40	1	0.064020
6	1	0.064020
10	1	0.064020

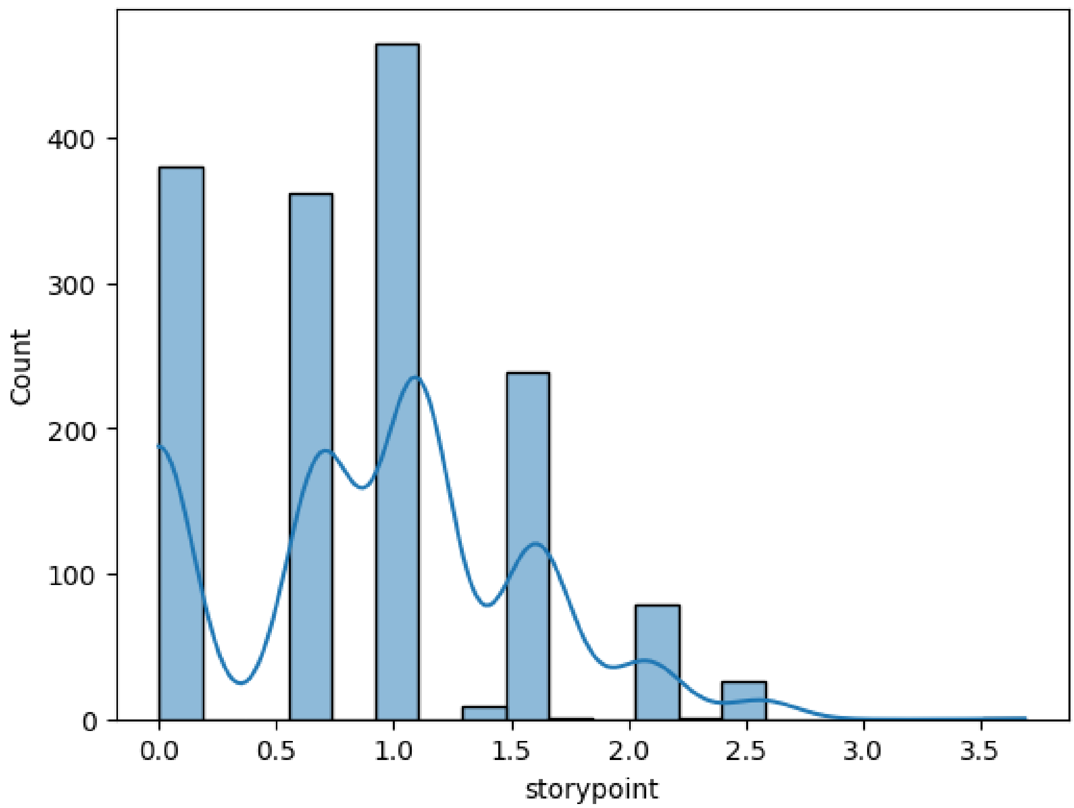
At the first sight, this data is bad. Then take a look at the statistic values, this data is even worse. Its distribution of the label is **right-skewed** and **leptokurtis**. This means if we use this to train model, the right side of the data can be the outliers and make the models become unsuable.

I will try 2 solutions: - Use log-scale on the label - Remove all the examples with label greater than a threshold (20, 30 or 40)

The first solution: logarithm magic

[ ]:
```
sns.histplot(np.log(all_data['storypoint']), bins=20, kde=True)
```

[ ]: <Axes: xlabel='storypoint', ylabel='Count'>



[ ]:
```
print('Skewness:', np.log(all_data['storypoint']).skew())
print('Kurtosis:', np.log(all_data['storypoint']).kurt())
```

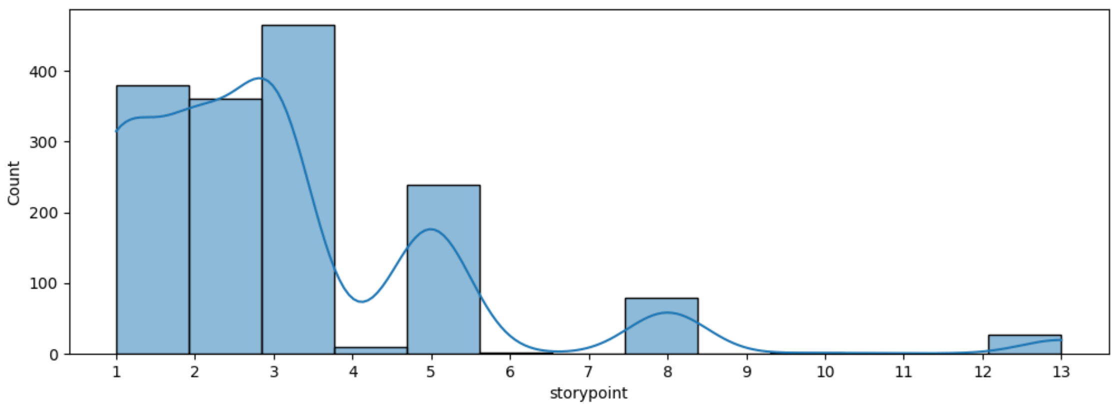
```
Skewness: 0.22513280116895606
Kurtosis: -0.34607356217908647
```

The second solution: Dismantle and Cleave

[ ]:
```
threshold = 13 # This threshold means that we will take all the examples with␣
↪story points less than or equal to 20

new_data = all_data[all_data['storypoint'] <= threshold]
plt.figure(figsize=(12, 4))
plt.xticks(np.arange(0, max(new_data['storypoint']) + 1, 1))
sns.histplot(new_data['storypoint'], bins=threshold, kde=True)
print('Fitered percentage: ', round(1 - new_data.shape[0] / all_data.shape[0],␣
↪2) * 100, '%')
```

```
Fitered percentage:  0.0 %
```



Input exploration The input of this problem is 2 texts: title and description. First we will find some statistics:

[ ]:
```
title_lengths = all_data['title'].apply(lambda x: len(x.split(' ')))
print('Title analysis:')
print('    - Mean length:', round(title_lengths.mean()))
print('    - Min length:', title_lengths.min())
print('    - Max length:', title_lengths.max())

description_lengths = all_data['description'].apply(lambda x: len(x.split(' '))␣
↪if type(x) != float else 0)
print('Description analysis:')
print('    - Mean length:', round(description_lengths.mean()))
print('    - Min length:', description_lengths.min())
print('    - Max length:', description_lengths.max())
```

```
Title analysis:
   - Mean length: 5
   - Min length: 1
   - Max length: 14
```

```
Description analysis:
   - Mean length: 76
   - Min length: 0
   - Max length: 1041
```

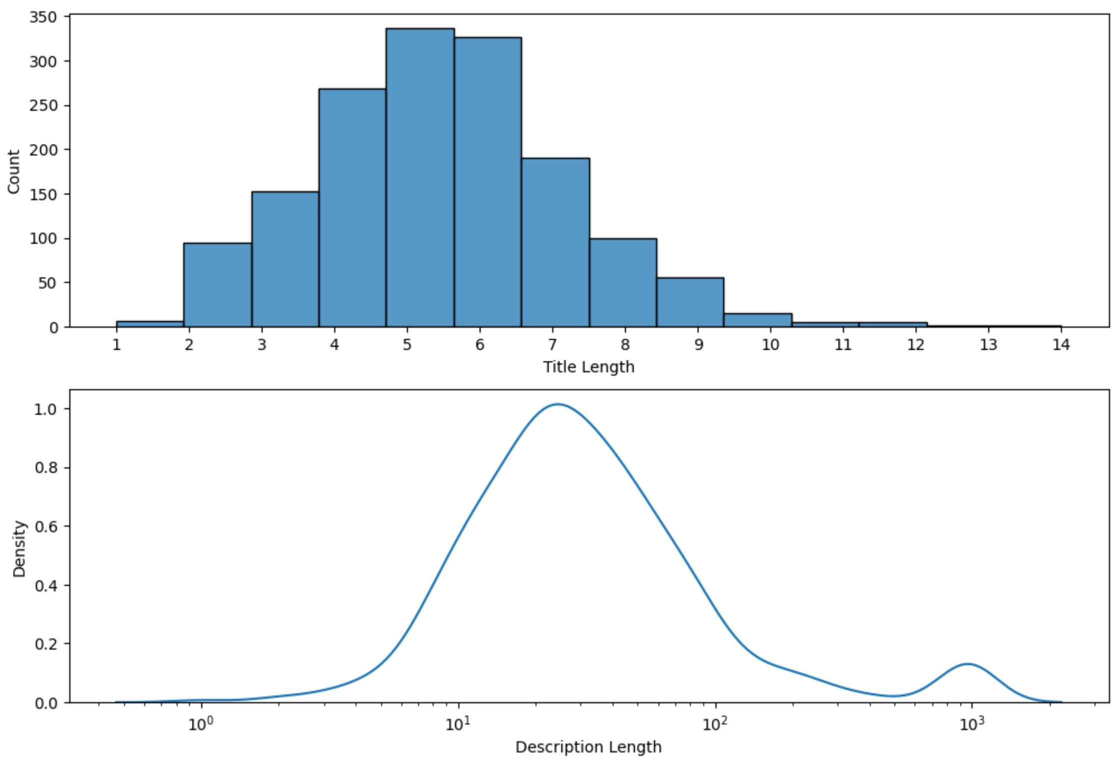
Plot the histogram of the title length and KDE of the description length (exclude 0):

[ ]:
```python
plt.figure(figsize=(12, 8))

plt.subplot(2, 1, 1)
plt.xticks(np.arange(0, max(title_lengths) + 1, 1))
plt.xlabel('Title Length')
sns.histplot(title_lengths, bins=max(title_lengths))

plt.subplot(2, 1, 2)
plt.xlabel('Description Length')
plt.xscale('log')
sns.kdeplot(description_lengths[description_lengths > 0])
```

[ ]:
```
<Axes: xlabel='Description Length', ylabel='Density'>
```



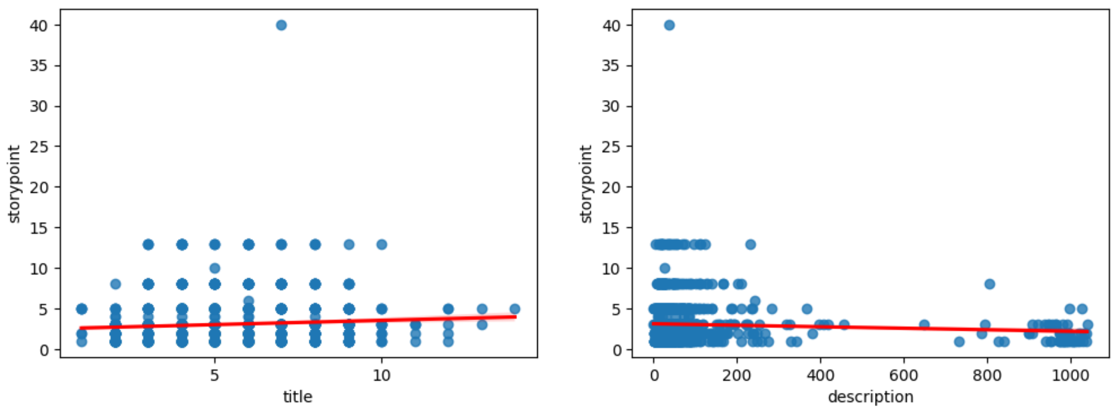
I think we should check the correlation between title length and description length:

[ ]:
```python
plt.figure(figsize=(12, 4))

plt.subplot(1, 2, 1)
plt.xticks(np.arange(0, max(all_data['title'].apply(lambda x: len(x.split('␣
↪')))) + 1, 5))
sns.regplot(x=all_data['title'].apply(lambda x : len(x.split(' '))),
            y=all_data['storypoint'],
            line_kws={'color': 'red'})

plt.subplot(1, 2, 2)
sns.regplot(x=all_data['description'].apply(lambda x : len(x.split(' ')) if␣
↪type(x) != float else 0),
            y=all_data['storypoint'],
            line_kws={'color': 'red'})
```

[ ]: <Axes: xlabel='description', ylabel='storypoint'>



Nope, no correlation at all

Let dive deeper in the input:

Title analysis:

[ ]:
```python
count_vectorizer = CountVectorizer()
count_vectorizer.fit(all_data['title'])

dictionary = pd.DataFrame(list(count_vectorizer.vocabulary_.items()),␣
↪columns=['word', 'frequency'])
dictionary.sort_values(by='frequency', ascending=False, inplace=True)
print(dictionary.shape)
dictionary.head(10)
```

(2283, 2)

[ ]:

```
                                                    word  frequency
2101                                          zookeepers       2282
293   zookeepermastercontenderdetectortestmasterdete…       2281
996                                            zookeeper       2280
158                                                znode       2279
1460                                                zero       2278
1435                                                 yum       2277
2072                                                 yet       2276
658                                                xargs       2275
1304                                             wrongly       2274
264                                                wrong       2273
```

Description analysis:

[ ]:

```python
count_vectorizer = CountVectorizer()
count_vectorizer.fit(all_data[all_data['description'].isnull() ==␣
 ↪False]['description'])

dictionary = pd.DataFrame(list(count_vectorizer.vocabulary_.items()),␣
 ↪columns=['word', 'frequency'])
dictionary.sort_values(by='frequency', ascending=False, inplace=True)
print(dictionary.shape)
dictionary.head(20)
```

```
(10899, 2)
```

[ ]:

```
                                                     word  frequency
10412                    zzznprocessprocessbasevisiterkns      10898
7717   zznprocessprocessmanagerinitthreadsevenkulrkst…      10897
8396   zznprocessdispatchinothingnsasyncexecutorproce…      10896
6376   zznprocessdispatchinothingnmesosinternalslavem…      10895
7711   zznprocessdispatchinmesosinternalcommandexecut…      10894
9729   zznprocessdispatchibnmesosinternalslavemesosco…      10893
5098   zznkprocessfutureisseonanyizndockerinspecterks…      10892
5112   zznkprocessfutureioptioniieeonanyizndockerinsp…      10891
5126   zznkprocessfutureioptioniieeonanyistbindifpfvr…      10890
5097   zzndockerinspecterkssrknprocessownedinspromise…      10889
5110   zzndockerinspecterkssrknprocessownedinspromise…      10888
1160                             zookeepertestservercpp      10887
1161                                zookeepertestserver      10886
7688                                      zookeepertest      10885
10772                                  zookeepernetwork      10884
1661   zookeepermastercontenderdetectortestmasterdete…      10883
7142                     zookeepergroupprocessupdatedlong      10882
7186   zookeepergroupprocessoperatorzookeepergrouppro…      10881
7147                            zookeepergroupprocesslong      10880
7139                           zookeepergroupprocesscache      10879
```

Yet I don’t find any thing special about the words in input except so many things are bad.

1.4.2 Solving strategies

My first intuitation in this problem is that the hard part is not on the algorithm we use, it is on the **embedding** part. Therefore, in case the given embedded datasets work not properly, I will use a better embedding method which is **Bidirectional Encoder Representations from Transformers (BERT)**. Also, I will try an old way to embedding the text too: **Bag of words**.

In conclusion, I will have 4 ways to embed the text: - doc2vec (already available) - Look up (already available) - Bag Of Words - BERT

About algorithm, I will try all the regression algorithm that may give a good result:

- Ridge Regressor
- Support Vector Regressor
- Random Forest Regressor
- Gradient Boosting
- XGBoost
- Lightgbm
- Blended

Maybe, we can change the problem to the classification problem with 100 labels (desparation confirmed). In the classification problem, I will use: - Support Vector Classifier - Softmax Regression (Multinomial Logistic Regression) - Random Forest - Adaboost - XGBoost

Thanks to the libaries, the implementation of all the algorithm shrinks to its minimum form.

At last, there is still a situation that all of mentioned model don't give a good result. This gamble is thrilling (hopeless).

"But would you lose?"

Nah, I'd win.